

3D Printing Heat Shields

Completed Technology Project (2017 - 2020)



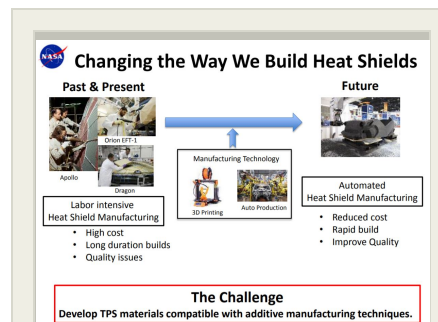
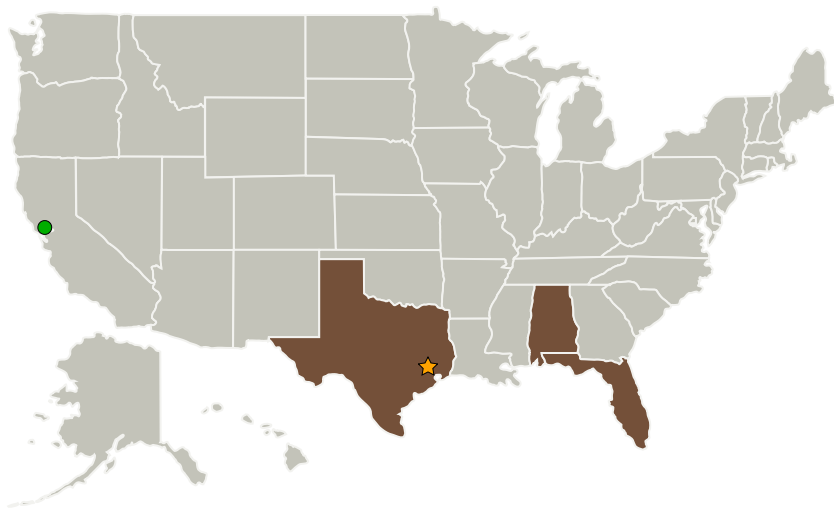
Project Introduction

This project intends to demonstrate the feasibility of 3D printing a heat shield using materials that perform well as TPS. Key features of a 3D printed heat shield include a monolithic heat shield without seams or gaps and a graded material with a robust layer near the surface and an insulative material at the structure. Once feasibility is demonstrated the candidate materials and 3D printing processes would be further developed and characterized for use on future NASA and commercial spaceflight vehicles. Follow-on projects, such as a STMD project, would conduct additional material development testing, develop techniques for applying the materials to structure and demonstrate the manufacture of a small capsule heat shield.

Anticipated Benefits

The goal of this project is to automate the processes for making and installing ablative TPS on large entry vehicles in order to significantly reduce the cost of TPS for future flight vehicles. The approach will be to develop new TPS materials that are compatible with 3D printing techniques which opens the door to automating TPS production and installation.

Primary U.S. Work Locations and Key Partners



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Organizations Performing Work	Role	Type	Location
★ Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
● Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California
Essentium Materials, LLC	Supporting Organization	Industry	
Oak Ridge National Laboratory(ORNL)	Supporting Organization	R&D Center	Oak Ridge, Tennessee
Texas A & M University-College Station(Texas A&M)	Supporting Organization	Academia	College Station, Texas
The University of Texas at Austin	Supporting Organization	Academia	Austin, Texas

Primary U.S. Work Locations

Alabama	Florida
Texas	

Project Transitions

▶ **October 2017:** Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Center Innovation Fund: JSC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Carlos H Westhelle

Principal Investigator:

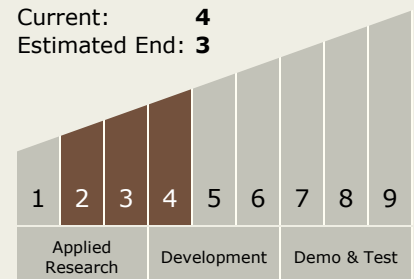
Stanley A Bouslog

Technology Maturity (TRL)

Start: 2

Current: 4

Estimated End: 3



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✓ **September 2020:** Closed out

Closeout Summary: During FY19 the 3D Printing Heat Shields project conducted material property tests on candidate thermoplastics that were 3D printed using a filament-based printer. Even though the char yield and thermal expansion characteristics were good, exposure to simulated reentry environments in a plasma torch resulted in swelling and the formation of an unstable char. Therefore, thermoplastics were not investigated further. The focus changed to thermoset resin mixtures and how to print them. A custom auger-based extruder was designed and built and installed on a commercial printer. With the assistance of Oak Ridge National Lab (ORNL), the candidate thermoset resin mixtures were reformulated for printability and then successfully printed at JSC and at ORNL. Test articles for plasma torch testing were printed by both JSC and ORNL and then tested. All of the thermoset resin mixture-based test articles tested performed well forming a stable char in the high-temperature flow field. Test articles for thermal conductivity and tensile testing are now being printed. The capability to deposit the material on a small sphere-cone shape representative of a heat shield for a small capsule was also demonstrated.

Technology Areas

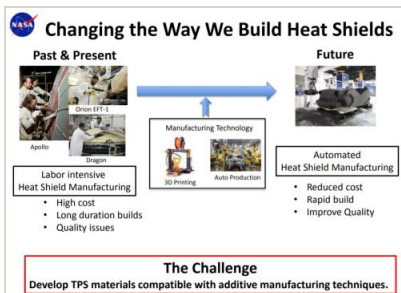
Primary:

- TX13 Ground, Test, and Surface Systems
 - └ TX13.2 Test and Qualification
 - └ TX13.2.2 Propulsion, Exhaust, and Propellant Management

Target Destinations

Earth, The Moon, Mars

Images



Project Image

3D Printing Heat Shields

(<https://techport.nasa.gov/image/35806>)

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VQ